Before The
Federal Communications Commission
Washington, DC 20554

In The Matter Of	)	
	)	
Digital Audio Broadcasting Systems	)	
And Their Impact On The Terrestrial	)	
Radio Broadcast Service	)	MM Docket No. 99-325

TO: The Commission:

Reply Comments of
Glen Clark & Associates

INTRODUCTION

The Commission is deliberating whether to adopt technical standards to permit the transmission of digital audio within the AM and FM broadcast bands and has solicited comments[1]. Glen Clark & Associates is a consulting engineering firm with expertise in the AM allocation process, having filed numerous AM Form 301 applications over the last 20 years. Additionally, the firm has deep expertise in modulation and spectrum issues, having previously been an active member of the Committee which authored the standards codified in 47CFR73.44 and having designed and manufactured AM audio processors which conformed to that standard.

Clear Channel Communications, Inc. ("Clear Channel") filed comments in MM Docket 99-325. Glen Clark & Associates concurs with the recommendations made by Clear Channel and wishes to support them with the engineering justification which follows.

As the Commission is well aware, the adoption of any new technical standard brings with it an issue of backward compatibility. Can the benefits of the new system be obtained without orphaning the "installed fleet" of receivers? This was true when stereo was added to FM. And it was true when color was added to black-and-white NTSC television. The same issue is present here.

In addition to the question of whether digital transmission can be made to work in the AM broadcast band, one must also be certain that the proposed digital

[1] See FCC Public Notice DA 02-899 dated April 19, 2002.

signal will not degrade the ongoing business enterprise of analog broadcasting until digital receivers are in widespread use. While progress is desirable, it is unwise to burn the bridge one is standing on to obtain it. Several parties, including Clear Channel, contend that adoption of the proposed IBOC standard will cause an undue amount of interference to the installed fleet of analog receivers. Clear Channel also proposed a change to the standard which it believes will mitigate the interference.

THE SOURCE OF THE PREDICTED INTERFERENCE

47CFR73.44(b) requires conventional AM transmissions to extend no further than 10 kHz on either side of the carrier frequency with signals of appreciable power. The Commission's system of allocating AM licenses[2] was founded on that base presumption.

The proposed IBOC system extends beyond the limits proscribed in 47CFR73.44(b). Due to this fact, the presently proposed standard is not a true IBOC ("In Band On Channel") system. As the majority of the digital data is actually transmitted in spectrum which is part of the two first-adjacent channels, the presently-proposed system is also an IBAC ("In Band Adjacent Channel") system. Looked at as a whole, it is a hybrid IBOC/IBAC system.

As the proposed digital signal is wider than the base presumption which the Commission used in formulating its allocation framework, the present framework may not provide sufficient separation between stations.

The attached Appendix B shows that a strong first-adjacent channel station transmitting the hybrid digital signal can cause interference to any legacy analog receiver. And a strong second-adjacent channel station transmitting the hybrid digital signal can cause interference to legacy analog receivers which have a bandwidth greater than 5 kHz.

CLEAR CHANNEL'S RECOMMENDATION

Clear Channel has recommended that the proposed IBOC standard be modified slightly by reducing the power permitted in the "primary" sidebands by 6 dB or more. The primary sidebands are those sidebands which are more than 10 kHz but less than 15 kHz removed from the carrier frequency.

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[2] Primarily 47CFR73.37 and 47CFR73.182

Figure 5 in the attached Appendix B shows that the "primary sidebands" are, in fact, the primary contributor to interference in the first-adjacent channel case. And Figure 3 in the attached Appendix B shows that the "primary sidebands" are the only contributor to interference in the second-adjacent channel case. As a result, reducing the power in the primary sidebands will mitigate both first- and second-adjacent channel interference. One change will fix two problems.

The issue of backward compatibility for the first- and second-adjacent channel cases are the only two issues of contention with the presently-proposed system. As Clear Channel's recommendations address these matters, they are well-founded and this firm supports them.

CLOSING COMMENTS

It should be noted that the design of a digital AM system which is backward compatible with legacy receivers and existing channel spacings and which is acceptable for both groundwave and skywave propagation is an incredibly difficult undertaking. The developers of the present system are to be applauded for their efforts, their capital investment and their accomplishments. This firm is a strong supporter of the concept of digital AM broadcasting and, with the condition of the single change proposed by Clear Channel, supports the adoption of the proposed AM IBOC standard.

Respectfully submitted,

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APPENDIX A

A TAXONOMY OF THE HYBRID BROADCASTING PROBLEM

***"ESTABLISHING A COMMON LANGUAGE
TO DESCRIBE THE PROBLEM"***

Before solving a problem, it is first required to develop a common language to discuss the problem. The two-by-two matrix in Figure 1 shows the four modulation cases which must be addressed in the design of a hybrid digital system. Knowing that there will be analog receivers and digital receivers plus there will be analog signals transmitted and digital signals transmitted, the four cases are:

Case 1) analog-to-analog interference,
Case 2) analog-into-digital interference,
Case 3) digital-into-analog interference and
Case 4) digital-to-digital interference.

DIGITAL TRANSMITTED SIGNAL	**Case 3 Digital-to-analog Interference**	**Case 4 Digital-to-digital Interference**
ANALOG TRANSMITTED SIGNAL	**Case 1 Analog-to-analog Interference**	**Case 2 Analog-to-digital Interference**
	ANALOG RECEIVER	**DIGITAL RECEIVER**

**FIGURE 1 - CATEGORIZATION
BY MODULATION SCHEME**

Cases 1 and 4 are interference caused by the same-mode operation. Cases 2 and 3 are undesired leakage between modes.

Case 1 is the present state of the broadcast band, that level of analog service presently provided. Case 4 is the performance of the digital system in the face of digital interference. Case 2 addresses the issue of whether the digital system can function in the presence of the legacy analog signal. Lastly, Case 3 addresses whether the addition of the digital signal will adversely affect the installed fleet of analog receivers. Restated, Case 3 asks whether the implementation of the digital signal will be strictly a move forward toward the digital world or whether, in the process of long term improvements, some loss of functionality in the legacy system will be experienced in the short term.

Present AM allocation standards[3] were developed based on the needs of the present analog system. Of course, these standards could not foresee and specifically provide for the needs of future technologies, such as digital. Therefore, the digital transmission system has been designed with the goal of being compatible with the existing spacing between AM stations.

The evaluation of a hybrid system must also be parsed in a second way. Above, it was parsed according to modulation scheme. It must also be parsed according to propagation mode. This is done in Figure 2.

SKYWAVE PROPGATION OF UNDESIRED SIGNAL	**Case C Skywave-to-Groundwave Interference**	**Case D Skywave-to Skywave Interference**
GROUNDWAVE PROPAGATION OF UNDESIRED SIGNAL	**Case A Groundwave-to-Groundwave Interference**	**Case B Groundwave-to-Skywave Interference**
	GROUNDWAVE PROPAGATION OF DESIRED SIGNAL	**SKYWAVE PROPAGATION OF DESIRED SIGNAL**

FIGURE 2 - CATEGORIZATION BY PROPAGATION METHOD

[3] Primarily 47CFR73.37 and 47CFR73.182

During the daytime, AM signals extend from the tower only by "groundwave" propagation. The signals travel, at most, a few hundred miles from the tower and, most often, to a much shorter distance. However, during nighttime hours, AM signals also radiate via "skywave" propagation. Signals reflect from the ionosphere and come back to earth at great distances from the tower, sometimes a thousand miles away. This parsing by propagation method also provides four cases:

Case A) groundwave-to-groundwave interference
Case B) groundwave-to-skywave interference
Case C) skywave-to-groundwave interference
Case D) skywave-to-skywave interference

The groundwave-to-groundwave case is specified as Case A in Figure 2 and, as AM signals propagate only by the groundwave method during daytime hours, Case A is the only case which must be considered during the daytime. At night, three additional modes must be considered.

Case C, interference to a desired groundwave signal by an undesired skywave signal is commonplace. Every station which operates at night is affected by this mode. An example in the Washington, DC area might be to try to listen to WMAL(AM), which is on 630 kHz. As other stations also operate at night on 630 kHz, weak skywave signals from these stations are superimposed on the WMAL service area. There are some places in the Washington, DC area where the distant skywave signals are noticeable and they limit the range of WMAL's nighttime service.

Case B, interference to a desired skywave signal by an undesired groundwave signal, is less commonly experienced, partly because people are most inclined to listen to local stations. Additionally, Case B and D interference can only be experience by Class A stations[4]. As there are fewer Class A stations than there are of any other class, Case B interference is less common than Case C interference. An example of Case B interference would be a listener near the WMAL towers attempting to listen to skywave service from WSM(AM) in Nashville. WSM operates on 650 kHz, two channels removed form WMAL. Near the WMAL towers, the WSM signal will be unlistenable. Case B interference is usually very localized

Case D, interference to a desired skywave signal by an undesired skywave signal occurs when the listener is at a great distance (usually more than 100 miles) from both the desired and the undesired station. An example of this might be to try to listen in the Washington, DC area to WLW(AM) in Cincinnati. WLW operates on 700 kHz and Washington is within WLW's legal "secondary service area". However, WOR operates in New York City on 710 kHz, one channel removed from WLW. It also delivers a strong skywave signal into the Washington, DC area. On some receivers, it may not be possible to listen to either signal due to the strong adjacent-channel signal from the other.

[4] A "clear channel" station, as defined in 47CFR73.21(a), which has a right to a "secondary service area", as defined in 47CFR73.14

CREATING COMPOUND CASES

Evaluation of the IBOC hybrid mode has been parsed into four cases, labeled 1 through 4, which specify the modulation scheme being considered. It has also been parsed into four cases, labeled A through D, which specify the propagation mode(s) being considered. It is possible to specify compound cases by combing a letter and a number.

For example, Case 1A reflects consideration of analog-to-analog interference in a groundwave-to-groundwave scenario. Case 4C reflects consideration of the digital-to-digital case in a skywave-to-groundwave scenario. Considering propagation mode and transmission mode, there are 16 possible cases. They are:

Case 1A) analog-to-analog, groundwave-to-groundwave
Case 1B) analog-to-analog, groundwave-to-skywave
Case 1C) analog-to-analog, skywave-to-groundwave
Case 1D) analog-to-analog, skywave-to-skywave
Case 2A) analog-to-digital, groundwave-to-groundwave
Case 2B) analog-to-digital, groundwave-to-skywave
Case 2C) analog-to-digital, skywave-to-groundwave
Case 2D) analog-to-digital, skywave-to-skywave
Case 3A) digital-to-analog, groundwave-to-groundwave
Case 3B) digital-to-analog, groundwave-to-skywave
Case 3C) digital-to-analog, skywave-to-groundwave
Case 3D) digital-to-analog, skywave-to-skywave
Case 4A) digital-to-digital, groundwave-to-groundwave
Case 4B) digital-to-digital, groundwave-to-skywave
Case 4C) digital-to-digital, skywave-to-groundwave
Case 4D) digital-to-digital, skywave-to-skywave

There is one final differentiation. And that is the frequencies of the desired and undesired stations. The above cases can be modified with the following suffixes to show the frequency relationship between the stations:

Suffix 0 – Co-channel stations
Suffix 1 – 1^{st}-Adjacent channel stations
Suffix 2 – 2^{nd}-Adjacent channel stations
Suffix 3 – 3^{rd}-Adjacent channel stations

As an example, Case 2A2 would be analog-to-digital interference via groundwave-to-groundwave propagation from a 2^{nd}-adjacent channel station. Case 3C1 would be digital-to-analog interference via skywave-to-groundwave propagation from a 1^{st}-adjacent channel station. This creates 64 total cases. While 64 cases may seem like an inordinate level of complexity, this is not a definition of the solution, it is a definition of the problem. As a result, there is no way to appeal the complexity of the problem. Accordingly, to obtain a full audit of the worth of a particular hybrid IBOC design, all 64 cases must be considered.

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APPENDIX B

UNDERSTANDING THE DIGITAL-INTO-ANALOG LEAKAGE MECHANISM

A system has been proposed where an analog signal and a digital signal will occupy the same RF frequency spectrum. It is desired that both the digital signal and the analog signal can be individually decoded at the receiving end. Digital receivers are, by nature, somewhat immune to "uncorrelated interference" and, for reasonable levels of analog interference, tend to ignore the analog signal. Field tests agree with theory and show that the present design is able to decode the digital signal in the presence of reasonable analog interference.

However, most existing analog receivers cannot discriminate between correlated and uncorrelated signals. Any power within the RF passband of the analog receiver will be turned into audio power at the speaker. As a result, reducing leakage from the digital signal into the analog receiver is accomplished primarily by keeping the power of the digital signal at a level low enough that the AM artifacts of the digital signal are masked by the analog modulation.

The following figures are useful to visualize how the leakage occurs between the digital and analog modes.

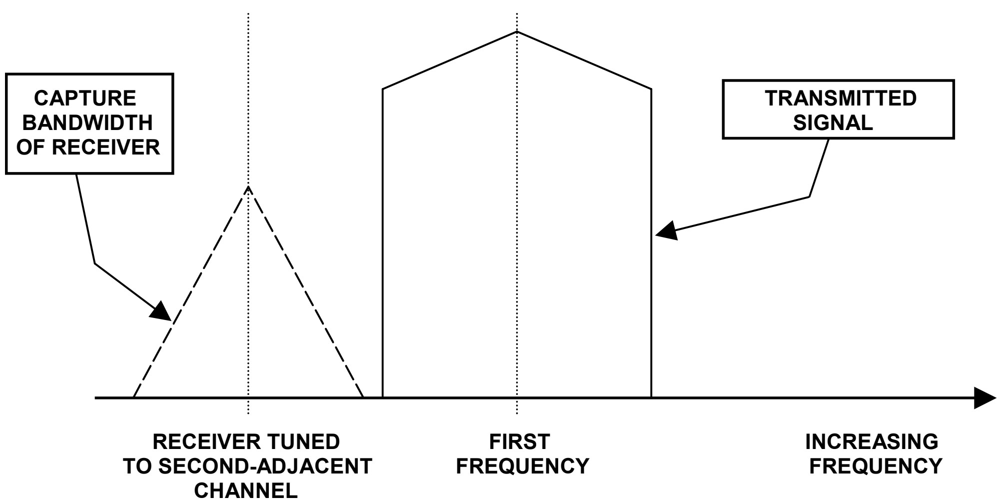

FIGURE 1 – PROTECTION FROM LEAKAGE IN THE ANALOG-INTO-ANALOG CASE

Figure 1 shows a typical AM signal which is, by law[5], limited to a maximum bandwidth of 10 kHz on either side of the AM carrier. Figure 1 also shows the reception curve of a receiver tuned to the second adjacent channel. Any radio energy within the dashed triangle in Figure 1 will show up as audio energy in the receiver's speaker. Neither the receiver passband nor the transmitted signal is more than 10 kHz wide. Therefore, together, they cannot total 20 kHz, which is the spacing between second adjacent channels. There is no overlap of the two spectrum diagrams in Figure 1. Therefore, a receiver tuned to the second-adjacent channel converts no analog signal from the first station into audio[6].

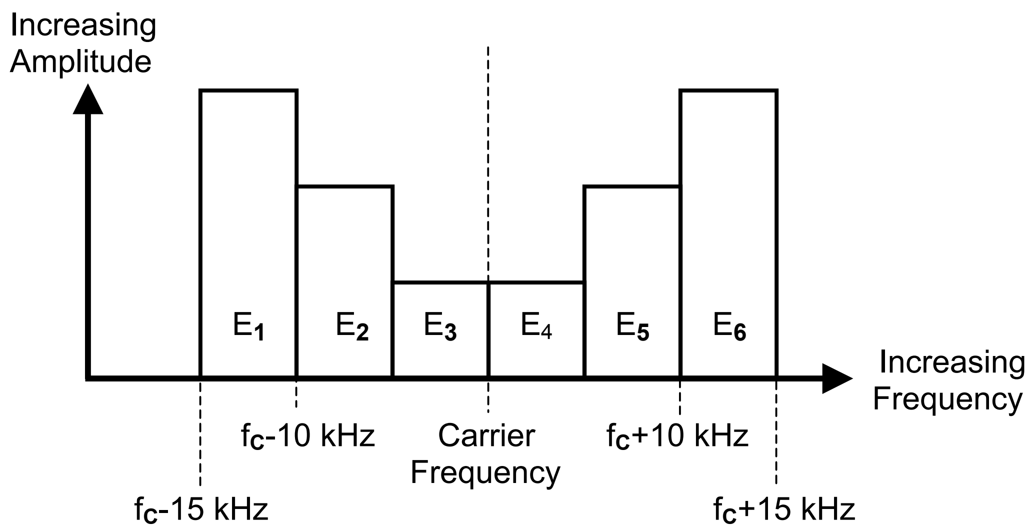

FIGURE 2 – PROPOSED ARRANGEMENT OF THE IBOC DATA

Figure 2 shows the organization of the proposed IBOC digital data. There are six data ensembles, which are labeled E_1 through E_6 in Figure 2. Each ensemble occupies 5 kHz. The total bandwidth of the digital data is from 15 kHz below the analog carrier to 15 kHz above the analog carrier.

Figure 3 shows this proposed digital signal presented with the same analog receiver bandpass from Figure 1. The proposed digital signal extends 5 kHz further toward the passband of a receiver tuned to a second-adjacent channel station than did the analog signal in Figure 1. Figure 3 shows that, for a receiver with a passband of more than 5 kHz, some of the energy from the transmitted digital signal falls within the capture bandwidth of the receiver. As most analog receivers employ simple envelope detectors which do not reject uncorrelated energy[7], the digital energy in the crosshatched area of overlap shows up in the receiver's speaker. The larger the crosshatched area, the more leakage there will be.

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[5] See 47CFR73.44(b).

[6] Except immediately around the tower of the second-adjacent channel station, where the strong signal will overwhelm the receiver and drive it into non-linear operation.

[7] "Synchronous AM detectors", which are rare, would be less susceptible to the interference effect of the second-adjacent channel digital signal.

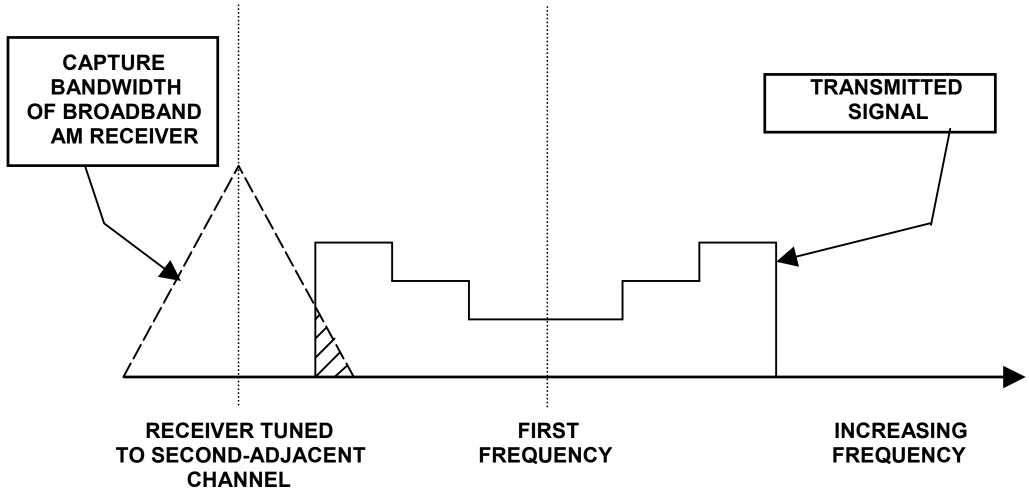


FIGURE 3 –LEAKAGE MECHANISM IN THE SECOND-ADJACENT CHANNEL, DIGITAL-INTO-ANALOG CASE WITH “WIDEBAND” (GREATER THAN 5 kHz) RECEIVER

There are many different makes and models of receivers in the “installed fleet”. Some of those receivers have a wider capture passband than do others. Figure 4 shows that, for a receiver with a passband of less than 5 kHz, none of the energy from the transmitted digital signal falls within the capture bandwidth of the receiver.

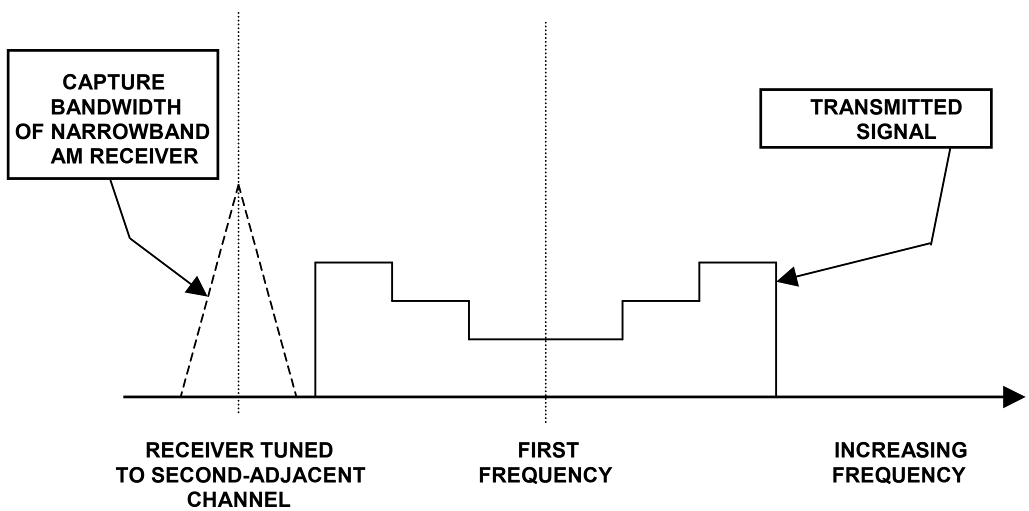
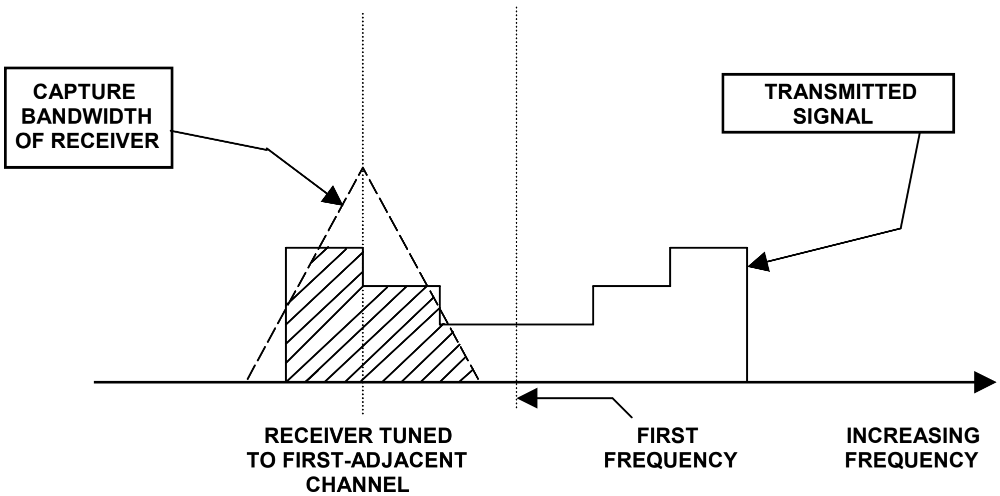


FIGURE 4 –LEAKAGE MECHANISM IN THE SECOND-ADJACENT CHANNEL, DIGITAL-INTO-ANALOG CASE WITH “NARROWBAND” (LESS THAN 5 kHz) RECEIVER

Figure 5 illustrates the leakage mechanism for first-adjacent channel, Digital-Into-Analog leakage. It is immediately obvious that the digital ensembles for a 1st-adjacent channel IBOC station will fall within the bandpass of both narrowband and wideband receivers.



<u>FIGURE 5 – LEAKAGE MECHANISM IN THE FIRST-ADJACENT CHANNEL, DIGITAL-INTO-ANALOG CASE</u>

It the text which follows, the descriptor "narrowband" will be used to refer to receivers which have a passband narrower than 5 kHz. The descriptor "wideband" will be used to refer to receivers which have a passband wider than 5 kHz. The following conclusions can be drawn:

1) Figure 3 demonstrates that, except in the case of overload, narrowband analog receivers <u>will not</u> be affected by transmission of the proposed, hybrid IBOC signal by a 2nd-adjacent channel station.

2) Figure 4 demonstrates that wideband analog receivers <u>will</u> be affected by transmission of the proposed, hybrid IBOC signal by a 2nd-adjacent channel station.

3) Figure 5 demonstrates that transmission of the proposed, hybrid IBOC signal by a 1st-adjacent channel station <u>will</u> be a factor, regardless of the bandwidth of the receiver.

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